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ABSTRACT

This document reports on the performance of Scottish primary students in mathematics and science. Students scored below the international average in mathematics and are ranked in the lower half of the range of countries involved in the study. In science, students scored above the international average and are ranked in the middle. Sections addressing performance in mathematics, examples of mathematics test items, Scottish features and international comparisons in mathematics, performance in science, examples of science test items, and Scottish features and international comparisons in science are included. (DDR)

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THE SCOTTISH OFFICE

Education and Industry Department

Achievements of Primary 4 and Primary 5 Pupils in Mathematics and Science

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Third International Mathematics and Science Study (TIMSS)

THE SCOTTISH OFFICE
Education and Industry Department

Achievements of Primary 4 and Primary 5 Pupils in Mathematics and Science

Third International Mathematics and Science Study (TIMSS)

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Contents

		Page
1	**Introduction**	**1**
	Sampling	1
	Administration	1
	Assessment instruments	2
MATHEMATICS		
2.1	**Performance in mathematics**	**3**
	Overall mean scores	3
	Differences between the lower and upper grades	4
	Benchmarks of performance	4
	Curriculum matching exercise	4
	Performance of 9 year olds	4
	Performance in different aspects of mathematics	5
	Gender and performance in mathematics	5
2.2	**Examples of mathematics test items**	**7**
2.3	**Scottish features and international comparisons in mathematics**	**13**
SCIENCE		
3.1	**Performance in science**	**16**
	Overall mean scores	16
	Differences between the lower and upper grades	17
	Benchmarks of performance	17
	Curriculum matching exercise	18
	Performance of 9 year olds	18
	Performance in different aspects of science	18
	Gender and performance in science	18
3.2	**Examples of science test items**	**19**
3.3	**Scottish features and international comparisons in science**	**22**
4	**Conclusions**	**24**

1 Introduction

The Third International Mathematics and Science Study (TIMSS), carried out in 1995, was the latest in a series of international studies carried out by the International Association for the Evaluation of Educational Achievement (IEA). In the past the IEA carried out separate international studies in the two subjects – in 1964 and 1980-82 in mathematics and 1970-71 and 1983-84 in science. These studies were of the attainment of 10, 13 and 14 year olds and on pupils in their final year at school. The International Assessment of Educational Progress (IAEP) also carried out a study of attainment in mathematics and science of 9 and 13 year olds in 1991.

Scotland is one of over 40 countries which participated in TIMSS, including most of the EU member states, other major English speaking countries, various Pacific rim countries and a number of Eastern European countries.

The main aims of TIMSS were to collect information about:

- pupils' knowledge and understanding of mathematics and science;
- mathematics and science curricula in the participating countries;
- teaching and learning practices in mathematics and science.

In order to achieve these aims, pupils were administered tests in mathematics and science, an analysis of curriculum guides and textbooks was carried out and questionnaires were completed by schools, teachers and pupils.

This report summarises the TIMSS results for primary 4 and primary 5 pupils in Scotland. A full listing of the international reports can be found on the World Wide Web: http://wwwcsteep.bc.edu/timss.

Sampling

Sampling was a two stage process involving first the random selection of schools, then the random selection of a class at each of the two grades containing the most 9 year olds. In Scotland these grades are primary 4 and primary 5. Details of the sampling procedure are provided in the TIMSS Technical Report Volume 1: Design and Development.

The overall sample for each country for TIMSS was 150 but, due to the small size of many of our primary schools, the Scottish target was 184. For the lower grade the response rate was 81% and for the upper grade it was 83%, when replacement schools were included. The target samples of pupils were 3,476 at the lower grade and 3,596 at the upper grade and response rates of 90% and 92% respectively were obtained.

Scottish pupils were the third youngest of all the countries; pupils were slightly younger in Iceland and Greece. However, along with England, New Zealand, Australia and Kuwait, they had the most years of formal schooling.

Administration

The tests and questionnaires were sent out to schools in April 1995. The tests were administered by the schools and were timed to allow the majority of pupils to complete them. The pupils then completed their questionnaires. School questionnaires were expected to be completed by the head teacher or his/her deputy and the teacher questionnaires were completed by the teachers of the classes that were tested.

The pupil questionnaire asked about home background, attitudes towards mathematics and science and perceptions of lessons in these subjects. The teacher questionnaire asked about education, training and experience, how teachers divided their time between teaching and teaching related activities, teaching approaches, resources available and views on teaching and learning in mathematics and science. The questionnaire for schools asked for background information about the school, organisational features

related to the teaching of mathematics and science, the availability of resources and the time devoted to the teaching of these subjects.

Assessment instruments

The assessments were in the form of written tests. Each pupil sat a test in one booklet, out of eight booklets in total, which contained mathematics and science tasks. All tests contained a common core of tasks, with the other tasks appearing in different versions of the test. Tests were allocated to pupils in rotation, so only a few pupils in each school took the same test. The total test battery consisted of 102 mathematics tasks and 97 science tasks. The tests were administered in two sessions taking approximately 60 minutes in total.

The same tasks were used in all countries in order that comparisons could be made of their relative performance. However, in addition, a curriculum matching exercise was carried out which involved each country in defining what tasks were covered in its curriculum. A further analysis was then done for all countries based only on these tasks to provide performance measures relevant to that country.

The tasks included multiple choice questions, short answer questions and extended response questions. About a quarter of the tasks were in a free response format. The reporting categories used in this report are:

Mathematics

- whole numbers
- fractions and proportionality
- measurement, estimation and number sense
- data representation, analysis and probability
- geometry
- patterns, relations and functions

Science

- earth science
- life science
- physical science
- environmental issues and the nature of science

2.1 Performance in mathematics

This report compares the mathematics performance of Scottish pupils with that of pupils in the other countries participating in TIMSS. The comparisons are made in terms of:

- overall mean scaled scores
- mean scores in the six reporting categories
- mean scores on the tasks identified in the curriculum matching exercise
- performance on selected individual tasks

The grades selected for this phase of testing in TIMSS were the two grades containing the greatest number of 9 year olds. In Scotland these grades were primary 4 and primary 5. Separate mean scores were calculated for pupils at each grade and median scores for pupils at both grades who were 9 years old at the time of testing for countries in which the two grades contained at least 75% of nine year olds. Where appropriate, comparisons are made with the 1991 IAEP results. Unless otherwise stated, 24 countries took part in the lower grade tests and 26 countries in the upper grade tests. In comparing the results from the different countries it should be borne in mind that Scottish pupils were amongst the youngest pupils in the study, although they had more years of formal schooling than pupils in most other countries.

Overall mean scores

The international scores for the lower and upper grades in all countries are presented in Table 1. These are scaled scores calculated using plausible values procedures which are explained in the second TIMSS Technical Report. The overall mean score for the lower grade was 470, compared to Scotland's 458, and for the upper grade it was 529, compared to Scotland's 520. Overall Scotland's ranking was 15th out of 24 countries at the lower grade and 16th out of 26 countries at the upper grade, including countries which did not meet TIMSS sampling criteria. However, comparisons with countries which did not meet the sampling criteria should be treated with caution.

Table 1: Mean scaled scores in mathematics for each grade.

Country	Mean Score Lower Grade	Mean Score Upper Grade
Korea	561	611
Singapore	552	625
Japan	538	597
Hong Kong	524	587
Czech Republic	497	567
Netherlands	493	577
Austria	487	559
Australia	483	546
USA	480	545
Ireland	476	550
Canada	469	532
Latvia	463	525
Scotland	**458**	**520**
England	456	513
New Zealand	440	499
Cyprus	430	502
Greece	428	492
Portugal	425	475
Norway	421	502
Iceland	410	474
Iran	378	429
Countries not meeting TIMSS sampling criteria		
Slovenia	488	552
Hungary	476	548
Israel	–	531
Thailand	444	490
Kuwait	–	400

Most of the Pacific rim countries did very well in mathematics, with Korea, Singapore, Japan and Hong Kong leading in the performance table. Thailand was the exception and was rated 17th and 22nd at the lower and upper grades respectively.

Of the European countries, The Netherlands, Austria and Ireland did well. England was not

significantly different from Scotland, and Greece, Portugal, Norway, Cyprus and Iceland performed more poorly.

Of the four Eastern European countries, the Czech Republic, Slovenia and Hungary performed well, and Latvia performed very similarly to Scotland.

Other English speaking countries varied in their performance. Australia and the USA performed quite well, Canada performed about the same as Scotland and New Zealand performed more poorly than Scotland.

Table 2 shows Scotland's position relative to other countries in statistical terms. Twelve countries performed significantly better than Scotland and four countries performed the same as Scotland at both grades. The remaining seven countries at the lower grade and nine countries at the upper grade performed significantly more poorly than Scotland.

We can make a few comparisons with IAEP carried out in 1991. Of the countries which participated in TIMSS and in the IAEP, all were rated similarly in both studies in relation to Scotland except Slovenia and the USA, which performed more poorly than Scotland in IAEP and better than Scotland in TIMSS.

Differences between the lower and upper grades

The same tests were taken by each grade and the differences in scores between the lower and upper grade gives an indication of the gains made in this year. In Scotland the gain in score was 62, compared to the international average gain of 59. Scotland's gain was the 16th greatest of the 24 countries. The differences between grades varied from 81 (in Norway) to 46 (in Thailand).

If we look at the mean differences in scores in the different aspects of mathematics in Scotland, we see that the greatest gain was in data representation, analysis and probability and the least gain was in geometry.

If we regard the average gain of 59 score points between the grades as representing a year's progress, then four countries at both the lower and upper grades can be regarded as being more than a year ahead of Scotland in mathematics. They are Hong Kong, Singapore, Japan and Korea.

Benchmarks of performance

If we regard the mean scores over all countries for the top 10%, the top 25% and the top 50% of pupils as benchmarks of performance, we can compare them with the percentage of pupils in each country reaching these benchmarks. At the lower grade, 5% of Scottish pupils attained the 10% benchmark, 16% attained the 25% benchmark and 41% attained the 50% benchmark and Scotland was ranked 16th for all three benchmarks. At the upper grade the equivalent percentages were 6%, 18% and 43% for the three benchmarks and Scotland was ranked 15th, 16th and 16th respectively on each of the benchmarks.

Curriculum matching exercise

In the curriculum matching exercise, the TIMSS tasks were scanned by each country to identify those which were within their curriculum. The performance of pupils was then assessed on the basis of the tasks judged to be within the curriculum of each country. The tasks identified as being within Scotland's curriculum had total unscaled scores of 46 score points at the lower grade and 92 score points at the upper grade, compared to the total of 113 score points for all of the tasks at both grades. Scotland's scores were 54% at the lower grade and 60% at the upper grade on the selected tasks and her rankings were 13th at both grades (out of 22 countries at the lower grade and 24 countries at the upper grade). This was only a slight improvement on Scotland's ranking on all the test items which suggests the TIMSS tests were well matched to our curriculum.

Performance of 9 year olds

In 22 of the TIMSS countries, the percentage of 9 year olds in the two grades tested exceeded 75%. For these countries the median scores have been taken as the best indicator of performance. Scotland's ranking in terms of her median score was 8th, a major

Table 2: Scotland's position relative to other countries

	Lower Grade	Upper Grade
Countries scoring significantly higher than Scotland	Korea, Singapore, Japan, Hong Kong, Czech Republic, Netherlands, Slovenia, Austria, Australia, USA, Hungary, Ireland	Singapore, Korea, Japan, Hong Kong, Netherlands, Czech Republic, Austria, Slovenia, Ireland, Hungary, Australia, USA
No significant difference from Scotland	Canada, Latvia, England, Thailand	Canada, Israel, Latvia, England
Countries scoring significantly lower than Scotland	New Zealand, Cyprus, Greece, Portugal, Norway, Iran, Iceland	Cyprus, Norway, New Zealand, Greece, Thailand, Portugal, Iceland, Iran, Kuwait

improvement on her overall rankings due to the younger age of the Scottish pupils compared to the pupils in nearly every other country.

Performance in different aspects of mathematics

There were different numbers of tasks in the different aspects of mathematics:

Whole numbers	25 tasks
Fractions and proportionality	21 tasks
Measurement, estimation and number sense	20 tasks
Data representation, analysis and probability	12 tasks
Geometry	14 tasks
Patterns, relations and functions	10 tasks

The performance of Scottish pupils varied in the different aspects of mathematics covered by the tests. The differences are exemplified in Table 3 by showing Scotland's ranking in the different aspects. Performance was relatively poor on whole numbers, relatively good on data representation, analysis and probability and very good on geometry.

Gender and performance in mathematics

At the lower grade, boys did better than girls in 19 countries out of 24, but the differences were only significant in six of them. At the upper grade, boys did better than girls in 16 countries out of 25, but the differences were only significant in three of them. In Scotland, boys scored higher than girls at the lower grade, but the difference was not significant. At the upper grade, boys and girls scored the same.

Table 3: Scotland's rankings on aspects of mathematics

Aspect	Lower grade ranking	Upper grade ranking
Whole numbers	16	18
Fractions and proportionality	14	16
Measurement, estimation and number sense	14	16
Data representation, analysis and probability	13	11
Geometry	2	4
Patterns, relations and functions	15	16

2.2 Examples of mathematics test items

Whole numbers

Example 1: Choose the largest number

Which of these is the largest number?

A. 2735
B. 2537
C. 2573
D. 2753

Scotland's performance

	Percentage correct	International ranking
Lower grade	68	18
Upper grade	85	18

Example 2: Complete number sentence

Here is a number sequence.

$2000 + \square + 30 + 9 = 2739$

What number goes where the $\square$ is to make this sentence true?

Answer: _____

Scotland's performance

	Percentage correct	International ranking
Lower grade	21	22
Upper grade	47	23

Fractions and proportionality

Example 3: Longest box on shelf

Julie put a box on a shelf that is 96.4 centimeters long. The box is 33.2 centimeters long. What is the longest box she could put on the rest of the shelf? Show all your work.

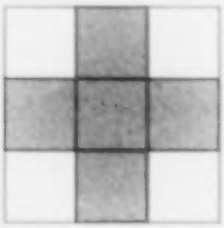
Answer: _____

Scotland's performance

	Percentage correct	International ranking
Lower grade	8	12
Upper grade	27	12

Example 4: Fraction of figure shaded

Part of the figure is shaded.



What fraction of the figure is shaded?

A. $\frac{5}{4}$

B. $\frac{4}{5}$

C. $\frac{6}{9}$

D. $\frac{5}{9}$

Scotland's performance

	Percentage correct	International ranking
Lower grade	40	11
Upper grade	66	13

Measurement, estimation and number sense

Example 5: Best estimate of clothespin mass

The weight (mass) of a clothespin is 9.2 g. Which of these is the best estimate of the total weight (mass) of 1000 clothespins?

A. 900 g
B. 9,000 g
C. 90,000 g
D. 900,000 g

Scotland's performance

	Percentage correct	International ranking
Lower grade	40	13
Upper grade	50	15

Example 6: Length of rectangle

A thin wire 20 centimeters long is formed into a rectangle. If the width of this rectangle is 4 centimeters, what is its length?

A. 5 centimeters
B. 6 centimeters
C. 12 centimeters
D. 16 centimeters

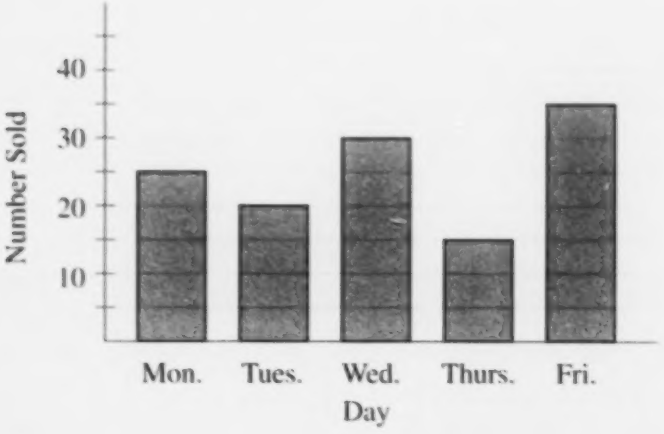
Scotland's performance

	Percentage correct	International ranking
Lower grade	26	4
Upper grade	24	8

Data representation, analysis and probability

Example 7: Bar graph: cartons sold on Monday

The graph shows the number of cartons of milk sold each day of a week at a school.



How many cartons of milk did the school sell on Monday?

Answer: _____

How many cartons of milk did the school sell that week? Show your work.

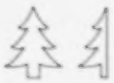
Answer: _____

Scotland's performance

	Percentage correct	International ranking
Lower grade	63	10
Upper grade	83	10

Example 8: Pictograph of trees

The graph shows 500 cedar trees and 150 hemlock trees.

Cedar	
Hemlock	

How many trees does each represent?

Answer: _____

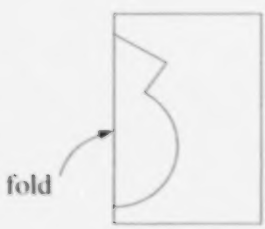
Scotland's performance

	Percentage correct	International ranking
Lower grade	35	8
Upper grade	56	8

Geometry

Example 9: Cut out shape

Craig folded a piece of paper in half and cut out a shape.



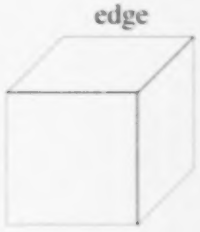
Draw a picture to show what the cut-out shape will look like when it is opened up and flattened out.

Scotland's performance

	Percentage correct	International ranking
Lower grade	60	6
Upper grade	76	5

Example 10: Edges of cube

This picture shows a cube with one edge marked. How many edges does the cube have altogether?



A. 6
B. 8
C. 12
D. 24

Scotland's performance

	Percentage correct	International ranking
Lower grade	39	9
Upper grade	44	10

Relations and functions

Example 11: True statement of ages

Henry is older than Bill, and Bill is older than Peter. Which statement must be true?

A. Henry is older than Peter.

B. Henry is younger than Peter.

C. Henry is the same age as Peter.

D. We cannot tell who is oldest from the information.

Scotland's performance

	Percentage correct	International ranking
Lower grade	58	11
Upper grade	65	14

Example 12: Operation to get B from A

What do you have to do to each number in Column A to get the number next to it in Column B?

Column A	Column B
10	2
15	3
25	5
50	10

A. Add 8 to the number in Column A.

B. Subtract 8 from the number in Column A.

C. Multiply the number in Column A by 5.

D. Divide the number in Column A by 5.

Scotland's performance

	Percentage correct	International ranking
Lower grade	24	13
Upper grade	31	18

2.3 Scottish features and international comparisons in mathematics

Characteristics of the schools	The average number of class teachers per school was 13.	This was just below average.
	Over 63% of the teachers had been at the school for more than 5 years.	This was slightly higher than average.
	Just over 300 pupils on average attended the schools.	This was considerably below average.
	On average just under 12 computers were available for use by teachers or pupils.	This was considerably above average.
	Average class size was just under 26.	This was slightly higher than average.
	Under 5% of the pupils were absent on a typical day.	This was considerably higher than average.
Characteristics of teachers	Over 90% of the teachers were female.	This was well above average.
	Teachers had been teaching for between 13 and 15 years.	This was less than in most other countries.
Mathematics teaching practices	Teachers spent between 240 and 260 minutes per week on mathematics.	This was above average.
	Between 79 and 85% of teachers always divided their classes into groups for mathematics.	This was much higher than in any other country.
	Between 68 and 73% of teachers allowed almost all pupils access to calculators in mathematics lessons.	This was higher than in any other country.
	11% of teachers never set mathematics homework.	This was higher than in all but 3 or 4 other countries.
	Over 25% of pupils reported that they spend no time studying mathematics or doing mathematics homework.	This was more than in all but 1 or 2 other countries.
	34 to 36% of teachers said that having pupils of different academic ability limited their teaching a great deal.	This was higher than in all but 2 or 3 other countries.

Mathematics teaching practices (cont'd)	14 to 16% of teachers said a high pupil-teacher ratio limited their teaching a great deal.	This was less than average.
	93% of schools provided remedial teaching in mathematics.	This was slightly higher than average.
	Just over 70% of schools provided enrichment activities in mathematics.	This was slightly above average.
	91 to 95% of pupils reported using calculators in most or some mathematics lessons.	This was higher than any other country.
	67 to 73% of pupils reported using computers in most or some mathematics lessons.	This was higher than any other country.
	93% of pupils reported working in pairs or small groups in most or some mathematics lessons.	This was higher than in any other country.
	Over 88% of pupils reported using things from real life to solve mathematics problems in most or some lessons.	This was well above average.
Characteristics of pupils	About 30% of pupils reported having over 200 books at home.	This was slightly above average.
	83 to 89% of pupils reported having a computer at home.	This was higher than in all but one other country.
	Between 23% and 27% of pupils reported watching TV or videos for more than 3 hours per day.	This was about average.
	13 to 16% of pupils reported playing computer games for more than 3 hours per day.	This was higher than in all but one other country.

Pupils' views	84 to 86% of pupils said they liked mathematics or liked it a lot.	This was just above average.
	Over 97% of pupils reported that their mothers thought it was important they did well in mathematics.	This was well above average.
	97% of pupils reported that they thought it was important they did well in mathematics.	This was slightly above average.

3.1 Performance in science

Comparisons are made between the science performance of Scottish pupils and pupils in other countries which participated in TIMSS. Some of these comparisons are of scaled scores derived using plausible values procedures which are described in the second TIMSS Technical Report. The comparisons are made of:

- overall mean scores
- mean scores in the four reporting categories
- mean scores on tasks identified in the curriculum matching exercise
- performance on selected tasks

Separate mean scores are shown for the two stages which contained the most 9 year old pupils. In Scotland these stages were primary 4 and primary 5. TIMSS also calculated median scores for pupils who were 9 years old at the time of testing. Where appropriate, comparisons are made with results from the International Assessment of Educational Progress carried out in 1991.

Overall mean scores

The international mean scores for the lower and upper grades in all countries are presented in Table 4. The international mean for the lower grade was 473, compared to Scotland's 484, and for the upper grade it was 524, compared to Scotland's 536. Overall Scotland's ranking was 12th out of 24 countries at the lower grade and 13th out of 26 countries at the upper grade, including those countries which did not meet TIMSS sampling criteria.

Two of the Pacific rim countries did well, Korea and Japan being ranked (on lower grade scores) first and second. Two others, Singapore and Hong Kong, did less well, being ranked 10th and 13th respectively at the lower grade. Thailand did considerably worse, being ranked 21st at the lower grade.

Of the European countries, Austria did well (and was ranked 5th at the lower grade and 3rd at the upper grade) and Scotland, England, The Netherlands and Ireland did better than average. Norway, Greece, Iceland, Portugal and Cyprus were significantly poorer than Scotland.

Two of the eastern European countries were better than average, namely the Czech Republic and Slovenia (ranked 8th and 11th at the lower grade). Latvia was a little below average and Hungary was significantly poorer than Scotland.

Table 4: Mean scaled scores in science at each grade

Country	Mean Score Lower Grade	Mean Score Upper Grade
Korea	553	597
Japan	522	574
United States	511	565
Australia	510	562
Austria	505	565
Netherlands	499	557
England	499	551
Czech Republic	494	557
Canada	490	549
Singapore	488	547
Scotland	**484**	**536**
Hong Kong	482	533
Ireland	479	539
New Zealand	473	531
Latvia	465	512
Norway	450	530
Greece	446	497
Iceland	435	505
Portugal	423	480
Cyprus	415	475
Iran	356	416
Countries not meeting TIMSS sampling criteria		
Slovenia	487	546
Hungary	464	532
Israel	–	505
Kuwait	–	401
Thailand	433	473

Other English speaking countries varied in their performance. The USA and Australia did well (ranked 3rd and 4th at the lower grade) and Canada was better than average. New Zealand was not significantly poorer than Scotland and was on the international mean score at the lower grade.

Table 5 shows Scotland's position relative to other countries. Scotland was significantly better than eight countries at the lower grade and nine countries at the higher grade, and was significantly worse than five countries at the lower grade and seven countries at the upper grade. There were no consistent differences between performances in TIMSS and IAEP, but there were indications that Hungary had done better in IAEP and Canada had done worse.

Differences between the lower and upper grades

The same tests were taken by each grade and the difference in scores gives an indication of the gains made in this year. In Scotland, the difference was 52 score points, and Scotland was ranked 17th out of 24 countries. The differences averaged 51 score points and ranged from 80 in Norway to 40 in Thailand. These gains are bigger than those between the two grades containing the most 13 year olds, which may be because there is a significant improvement in reading ability between the younger grades which helps the pupils in the upper grade to cope better with written questions.

If the average gain score of 51 is regarded as a year's progress, then only Korea was over a year ahead of Scotland.

There were no significant differences from Scotland's mean score difference in any of the content areas.

Benchmarks of performance

If we regard the mean scores over all countries for the top 10%, the top 25% and the top 50% of pupils as benchmarks of performance, we can compare the percentage of pupils in each country reaching these benchmarks. At the lower grade, 8% of Scottish pupils achieved the 10% benchmark, 24% the 25% benchmark and 49% the 50% benchmark, and Scotland's rankings were 9th, 9th and 11th respectively. At the upper grade, 9% of Scottish pupils achieved the 10% benchmark, 22% achieved the 25% benchmark and 50% achieved the 50% benchmark, and Scotland's rankings were 9th, 11th and 13th respectively.

Table 5: Scotland's position relative to other countries

	Lower Grade	Upper Grade
Countries scoring significantly higher than Scotland	Korea, Japan, USA, Australia, Austria	Korea, Japan, USA, Australia, Austria, Netherlands, Czech Republic
No significant difference from Scotland	England, Netherlands, Czech Republic, Canada, Singapore, Slovenia, Hong Kong, Ireland, New Zealand, Latvia	England, Canada, Singapore, Slovenia, Ireland, Hong Kong, Hungary, New Zealand, Norway
Countries scoring significantly lower than Scotland	Hungary, Norway, Greece, Iceland, Portugal, Cyprus, Iran, Thailand	Latvia, Israel, Iceland, Greece, Portugal, Cyprus, Iran, Kuwait, Thailand

Curriculum matching exercise

In the curriculum matching exercise, the TIMSS task bank was scanned by each country to identify the tasks which were within their curriculum. The performance of pupils was then assessed on the basis of the tasks judged to be within the curriculum of each country. The tasks rated as being within Scotland's curriculum had score points of 33 for the lower grade and 45 for the upper grade, compared to 105 score points for all of the tasks. This indicates that relatively few tasks were rated as being within Scotland's curriculum as defined by the 5-14 Environmental Studies guidelines.

Scotland's scores on the tasks within its curriculum were 61% at the lower grade, where its ranking was 12th (out of 22), and 69% at the upper grade, where its ranking was 10th (out of 24). This indicates that pupils at the lower grade did marginally worse on tasks rated as being within the Scottish curriculum than they did on all tasks and pupils at the upper grade did slightly better on the tasks within the Scottish curriculum.

Performance of 9 year olds

In 22 of the TIMSS countries, the percentage of 9 year olds in the two grades tested exceeded 75%. For these countries the median scores were considered to be the best indicator of the performance of the 9 year old pupils. Scotland's ranking in these countries was 5th out of the 22 countries, which is a considerable improvement on the overall grade rankings due to the younger average age of the Scottish pupils.

Performance in different aspects of science

The tests contained 97 science test items, of which 17 were in earth science (more akin to geography in Scotland), 41 were in life science, 30 were in physical science and 9 were in environmental issues and the nature of science. Scotland's rankings were similar in all the aspects of science tested, although the lower grade seemed to do slightly better in environmental issues and the nature of science and the upper grade seemed to do worse on life science. These rankings out of 24 countries at the lower grade and 26 countries at the upper grade are shown in Table 6.

Gender and performance in science

At the lower grade, boys performed better than girls in 20 countries (out of 24), but the differences were only significant in 9 countries. At the upper grade, boys performed better than girls in 22 countries (out of 25), but the difference was only significant in 10 countries. In Scotland, boys did better than girls at both grades, but the differences were not significant.

Table 6: Scotland's ranking on aspects of science

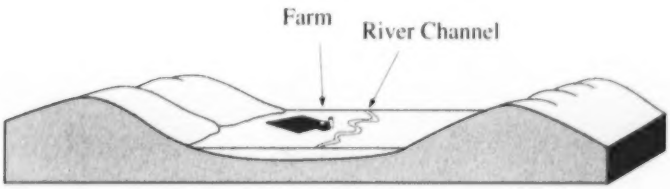
	Earth science	Life science	Physical science	Environmental issues and nature of science
Lower grade ranking	12	13	13	10
Upper grade ranking	15	17	14	13

3.2 Examples of science test items

Earth science

Example 1: River on plain: Good place for farming

The diagram shows a river flowing through a wide plain. The plain is covered with several layers of soil and sediment.



Write down one reason why this plain is a good place for farming.

Scotland's performance

	Percentage correct	International ranking
Lower grade	60	6
Upper grade	72	7

Example 2: Size of sun and moon

The Sun is bigger than the Moon, but they appear to be about the same size when you look at them from the Earth. Why is this?

Scotland's performance

	Percentage correct	International ranking
Lower grade	21	13
Upper grade	36	9

Life science

Example 3: Function of the heart

Write down one thing your heart does that helps the other parts of your body.

Scotland's performance

	Percentage correct	International ranking
Lower grade	37	6
Upper grade	53	6

Example 4: Why eat fruits and vegetables

What is the BEST reason for including fruits and leafy vegetables in a healthy diet?

A They have a high water content.
B They are the best source of protein.
C. They are rich in minerals and vitamins.
D. They are the best source of carbohydrate.

Scotland's performance

	Percentage correct	International ranking
Lower grade	61	10
Upper grade	59	16

Environmental issues and the nature of science

Example 5: Growing seeds in light or dark

To find out whether seeds grow better in the light or dark, you could put some seeds on pieces of damp paper and

A. keep them in a warm, dark place

B. keep one group in a light place and another in a dark place

C. keep them in a warm, light place

D. put them in a light or dark place that is cool

Scotland's performance

	Percentage correct	International ranking
Lower grade	32	7
Upper grade	36	11

Example 6: Oil spills

Write down as completely as possible why large oil spills in rivers and seas are harmful to the environment.

Scotland's performance

	Percentage correct	International ranking
Lower grade	14	12
Upper grade	23	15

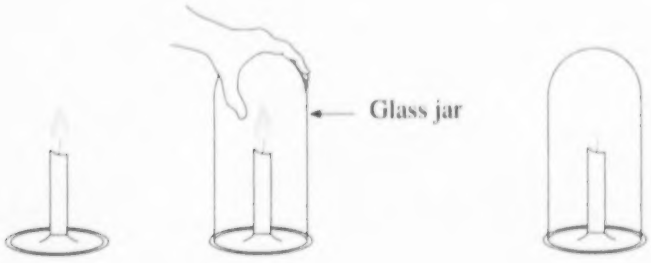
Physical science

Example 7: Glass over a candle

Scotland's performance

	Percentage correct	International ranking
Lower grade	45	15
Upper grade	66	11

When a glass jar is placed over a lighted candle, the flame goes out.



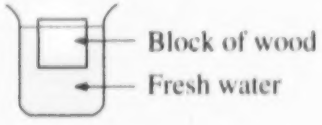
Why does this happen?

Example 8: Block floating in water

Scotland's performance

	Percentage correct	International ranking
Lower grade	29	12
Upper grade	31	17

The picture shows a block of wood floating in fresh water.



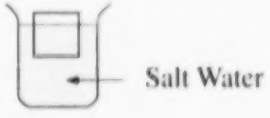
If this block were placed in salt water from the ocean, which picture shows what would happen?

A.

B.

C.

D.



3.3 Scottish features and international comparisons in science

Science teaching practices	Science was taught for between 59 and 71 minutes per week at the lower grade and between 67 and 78 minutes per week at the upper grade.	This was less than in most other countries.
	About 40% of teachers said their teaching was limited quite a lot or a great deal by high pupil teacher ratios.	This was lower than average.
	About 60% of teachers said their teaching was limited quite a lot or a great deal by having pupils with different academic abilities.	This was about average.
	Only 16 to 17% of teachers taught science as a separate subject.	This was lower than in all but two other countries.
	About 23% of schools provided remedial teaching in science.	This was about average.
	Between 20 and 24% of schools provided enrichment activities in science.	This was slightly below average.
	About 90% of pupils reported that in most or some science lessons teachers showed how to do science problems.	This was just above average.
	About 85% of pupils reported that in most or some science lessons they copied notes from the board.	This was about average.
	About 86% of pupils reported that in most or some science lessons they worked on science projects.	This was slightly above average.
	About 84% of pupils reported that in most or some science lessons they worked alone from worksheets and textbooks.	This was about average.
	About 83% of pupils reported that in most or some science lessons they used things from life to solve science problems.	This was above average.

Science teaching practices (cont'd)	About 82% of pupils reported that in most or some science lessons the teacher demonstrated experiments.	This was just above average.
	About 73% of pupils reported that in most or some science lessons they carried out experiments.	This was above average.
	About 70% of pupils reported that teachers set homework in most or some lessons.	This was below average.
	About 60% of pupils reported that they did not study or do science homework on a normal school day.	This was more than in all but 3 other countries.
Pupils' views	Over 90% of pupils agreed or agreed strongly that their mothers thought it important they did well in science.	This was about average.
	Over 90% of pupils thought it was important they did well in science.	This was about average.
	Just over 80% of pupils agreed or agreed strongly that they usually did well in science.	This was below average.
	Over 80% of pupils said they liked science or liked it a lot.	This was about average.

4 Conclusions

- Scotland's performance in mathematics relative to the other TIMSS countries was poor. Our scores were below the international averages and we were placed in the lower half of countries in terms of our performance. There appeared to have been some deterioration in our performance since the IAEP study in 1991.
- Scotland's performance in science was quite good. Our scores were above the international averages and we were placed among the top half of countries in terms of our performance. There was no indication of any deterioration in performance since the IAEP study in 1991.
- The top performing countries in mathematics were from the Pacific rim – Korea, Singapore, Japan and Hong Kong, but Thailand performed poorly. In science, Korea and Japan were again top performers, but Singapore and Hong Kong performed very similarly to Scotland. The USA and Australia did notably well in science.
- The gain in performance between primary 4 and primary 5 was just above the average gain for all countries in both mathematics and science.
- Because Scottish pupils were amongst the youngest in the study, the median performance of 9 year olds compared to other countries was substantially better than the performances of the two grade samples.
- Scottish pupils' performance was better in some aspects of mathematics and science than in others, but performance in geometry was notably good.
- In most countries, boys scored higher than girls in both mathematics and science, but the differences were significant in far fewer countries. In Scotland, boys scored higher than girls in all but the upper grade in mathematics, but the differences were not significant.
- The time spent teaching mathematics in Scotland was above average, but the time spent teaching science was much lower than average.
- Pupils' use of calculators and computers in mathematics lessons was higher than in any other country.
- Less homework is set in Scotland in both mathematics and science than in most other countries.
- Levels of TV and video watching in Scotland were about average, but pupils played computer games more than in almost all other countries.